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by V. P. Medvedev

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METHOD OF DETERMINING THE PROPAGATION VELOCITY OF PULSE WAVES **/79

V.P.Medvedev*

The recording of the pulse-wave velocity with a loop oscillograph of Russian manufacture, converting the mechanical vibrations of the arterial walls into electrical oscillations, is described with a sketch of the experimental setup. The velocity of the pulse was obtained by dividing the length of the aorta by the time lag of the pulse from the femoral artery with respect to the pulse from the carotid artery. The sphygmograms were analyzed through a 5 × magnifier attached to the oscillograph.

In the last decade, the propagation velocity of pulse waves through the arteries has attracted the attention of a number of authors as a means of diagnosing atherosclerotic arterial damage (Yu.T.Pushkar'; V.G.Kondrat'yev; N.K. Furkalo) and determining the arterial tonus (N.N.Savitskiy; V.P.Nikitin).

Today, the literature contains descriptions of many different methods /80
of pulse wave registration, which may be divided into methods with pneumo-optical recording and methods with conversion of the mechanical vibrations of

Fig.1 Sphygmograms of Healthy Subject, Recorded on the MPO-2 Loop Oscillograph with the Aid of Carbon Resistance Pickups
Top: sphygmogram of carotid artery. Bottom: sphygmogram of femoral artery. Rate of advance of tape: 25 mm/sec

the arterial wall into electrical oscillations, accomplished with the aid of various types of pickups (piezoelectric, tensometric, carbon microphones, and

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** Numbers in the margin indicate pagination in the original foreign text.

impedance plethysmographs). Of these, according to the literature, piezoelectric pickups are the most suitable, but they are brittle and often break down. The use of tensometric pickups requires special amplifiers and involves induction currents which are difficult to eliminate. Carbon microphones and impedance plethysmographs have not become popular.

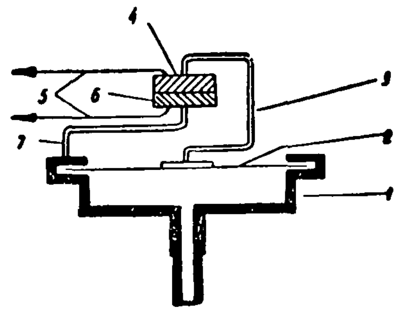

Fig.2 Diagram of Carbon Resistance Pickup Designed by Ye.M.Levinson
For explanation see text

The pulse curves according to which the propagation velocity of a pulse wave is determined are recorded by means of electrocardiographs, oscillographs, encephalographs, or specially designed instruments.

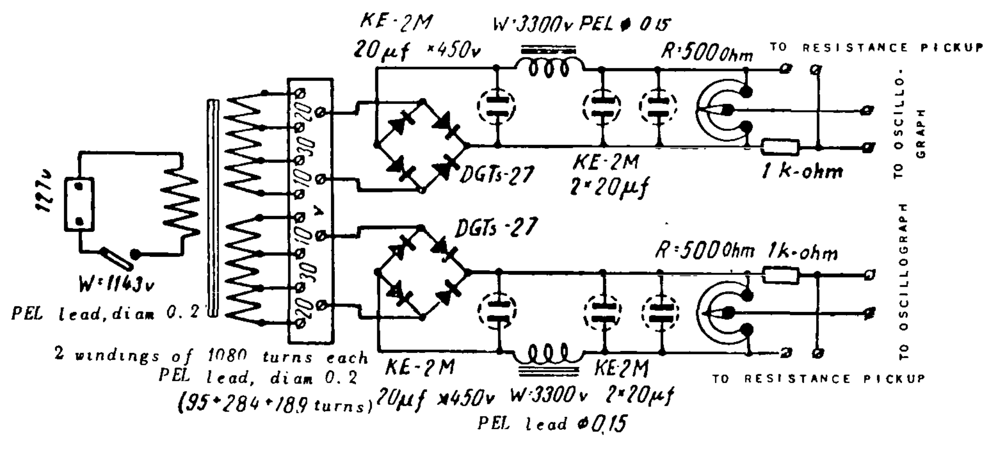

Fig.3 Electric Circuit of the Wheatstone Bridge for Carbon Resistance Pickups (Two Channels)

Soviet industry so far manufactures only one apparatus for determining the propagation velocity of pulse waves, namely, the mechanocardiograph of the N.N.Savitskiy system. However, this is manufactured in limited quantities and is expensive; therefore, the exploration of other methods of pulse wave recording, based on other equipment is definitely needed.

We recorded sphygmograms with the aid of the commercial MPO-2 loop oscillograph which is manufactured by domestic industry in large quantities and widely used in various branches of technology. We experimented with the conversion of the mechanical vibrations of the arterial wall to electrical oscillations with the aid of tensometric and piezoelectric pickups, as well as of the carbon resistance pickups developed by Engineer Ye.M.Levinson. The last proved to be most suitable and reliable and virtually fail-safe. To obtain the desired amplitude of the pulse curve, the sensitivity of these pickups must be adjusted. This is particularly important when using the MPO-2 oscillograph as the recording system, since the sphygmograms traced on film tape are, during their analysis, examined in the magnifying attachment of the oscillograph.

The slope of the pulse curves traced with the aid of these pickups does /81 not differ from that of piezograms (Fig.1).

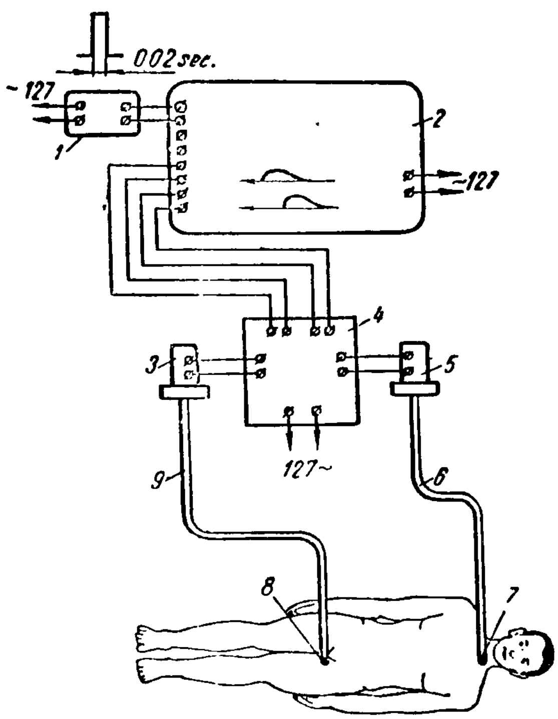

Fig.4 Diagram of Setup for Determining the Pulse-Wave Velocity
For explanation see text

The schematic diagram of the carbon resistance pickup is shown in Fig.2. As can be seen from this diagram, the principal part of this novel pickup is formed by pellets of activated carbon (4 and 6), one of which is mounted to a fixed bracket (7) and the other, to a mobile bracket (3). The swivel bracket is linked to a rubber membrane (2) built into the housing (1); air from a rubber hose connecting the pulse sensor with the pickup exerts pressure against this membrane. Both carbon tablets are connected by leads (5) to a measuring bridge which, in turn, is connected to the oscillograph loops. Two resistance pickups are included in the circuit of the Wheatstone bridge (Fig.3).

A schematic diagram of the setup used by us for determining the pulse-wave propagation velocity is shown in Fig.4. This setup consists of pulse sensors (7 and 8), metallic funnels sheathed in rubber membranes, rubber tubes (6 and 9) with relatively inelastic walls of 60 cm length, carbon resistance pickups (3 and 5), a measuring bridge (4), and an MPO-2 oscillograph to which a time marker (1) is attached.

Vibrations of the arterial wall are transmitted to the rubber membrane of the pulse sensor and agitate the air in the rubber tube, thus displacing the carbon resistors of the pickup, which unbalances the measuring bridge; this imbalance is recorded by the loops of the oscillograph. Pulse waves were recorded at a film tape speed of 25 and 50 mm/sec. The time marker marked 0.02 sec intervals. To determine the velocity of propagation of a pulse wave through the aorta, pulse curves from the femoral and carotid arteries were synchronously recorded on the same tape. To this end, one pulse sensor is placed on the left common carotid artery, at the level of the apex of the thyroid cartilage and the other, on the left femoral artery at the edge of Poupart's ligament. The velocity of propagation of the pulse wave was determined by dividing the length of the aorta by the time lag of the pulse from the femoral artery with respect to the pulse from the carotid artery. The length of the aorta was determined indirectly by the method described by N.N.Savitskiy.

Considering that sphygmograms are traced on perforated film tape 35 mm wide, the pickups were so adjusted that the amplitude of the pulse curves would not exceed 30 mm. The sphygmograms were analyzed with the aid of a magnifier attached to the oscillograph, which ensures a curve magnification of five times. This considerably facilitates analysis and contributes to the accuracy of calculations.

The setup described above was used to determine the pulse wave velocity through the aorta in 80 healthy subjects ranging in age from 19 to 50 years. The cholesterol, phospholipid, and lipoprotein-fraction content of the blood serum of these subjects was normal. The pulse wave velocity in the aorta of these subjects averaged 610 cm/sec, with fluctuations of from 430 to 770 cm/sec, whereas for 30 patients with atherosclerosis of the aorta and coronary arteries, 34 to 65 years old, this rate averaged 990 cm/sec, with fluctuations of from 740 to 1400 cm/sec. These figures tally with the figures given earlier in the literature (L.K.Lakshina; V.G.Kondrat'yev; V.A.Kirillov), except that we obtained the data with different equipment.

Incorporating a third channel and pickup into the setup makes it possible to record simultaneously three pulse curves on one tape. Thereby, it is also possible to determine the pulse wave velocity along arteries of the muscular type, which contributes to an accurate determination of the arterial tonus.

CONCLUSIONS

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1. The techniques of pulse wave recording must be further improved so as to make them simpler and more accessible.

2. Pulse curves can be successfully recorded with the aid of the commercial MPO-2 type loop oscillograph.

3. The fivefold magnification of the sphygmograms recorded in the MPO-2 type oscillographs greatly facilitates their analysis.

4. The proposed carbon resistance pickups are simple, rugged, and operationally reliable; they proved to be more convenient than tensometric and piezoelectric pickups.

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